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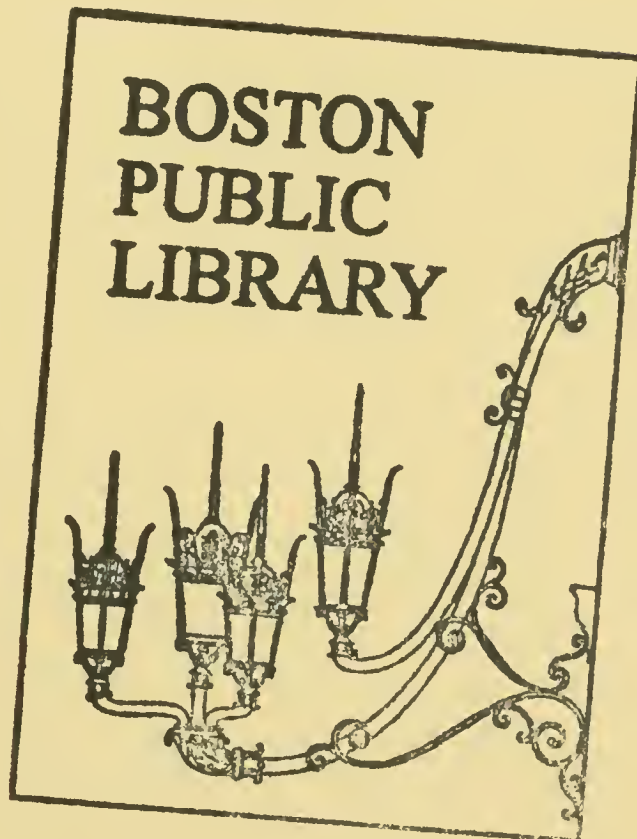
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Soils and Underground Conditions



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PRELIMINARY GEOTECHNICAL STUDIES
AND "PREMIUM" FOUNDATION COSTS
ARLINGTON/HADASSAH PROJECT
BOSTON, MASSACHUSETTS

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I. INTRODUCTION

1-01. GENERAL

This report presents the results of our evaluation of the geotechnical aspects of designing and constructing the proposed Gallery on the Garden. These evaluations have included an assessment of the currently known factors affecting site preparation, foundation design and proposed construction, as well as a determination of "premium" foundation costs related to development at the subject site.

During the course of this work, Goody, Clancy & Associates, Architects, have provided the design concept and layout of the planned facilities, including below-ground parking requirements. Based on this information, Haley & Aldrich, Inc. (H&A) has developed preliminary recommendations and criteria for building foundation systems.

The anticipated subsurface conditions on this site have been reviewed on the basis of both the historic soil borings in the area, and three new borings which have been made under our direction as noted herein to provide more specific information.

1-02. LIMITATIONS

The analyses and conclusions presented in this report are based, in part, on the site and subsurface conditions as inferred from the limited data available at this early date. Variations between site and subsurface conditions as presently interpreted and as disclosed by future explorations should be anticipated.

1-03. ELEVATION DATUM

Elevations used in this report are in feet and referenced to the Boston City Base datum, wherein El. 0.0 is 5.65 ft. below National Geodetic Vertical Datum (USC&GS MSL of 1929).

II. SITE AND SUBSURFACE CONDITIONS

2-01. SITE CONDITIONS

The project location occupies the area bounded by Boylston Street, Arlington Street, and Hadassah Way, and extends southward into a portion of Providence Street. The proposed building footprint area is approximately 49,000 sq. ft. with an additional 28,400 sq. ft. of surrounding site improvement area.

Of the proposed building footprint area, approximately 75 percent is currently occupied by existing structures. Among these structures is No. 250 Boylston Street, (the Garden Building) a structure whose foundation plans have been examined. No. 250 Boylston Street is a seven story stone masonry building which occupies the easternmost portion of the site. This structure is founded on a combination of spread footings and belled caissons. The remaining structures may be founded on footings, caissons, or wood piles. Wood piles were the most common foundation systems utilized in the Back Bay area prior to World War I.

In addition, an MBTA subway tunnel underlies Boylston Street to the north of the site and the Arlington Street Station occupies the area to the northwest of the project perimeter.

2-02. ANTICIPATED SUBSURFACE CONDITIONS

In order to determine the general subsurface conditions at the site, available test boring data were reviewed. These data include:

1. Test boring data summarized in "Boring Data from Greater Boston", published by BSCE, 1961.
2. Test boring data obtained by H&A as part of the adjacent Four Seasons Hotel project.
3. Test boring data included on MBTA plans for the Boylston Street subway.

In addition, a series of three additional test borings were completed at the site at the request of M.F.G. Associates under the direction of H&A by Guild Drilling Co., Inc. Locations of all referenced test borings have been indicated on the Boring Location Plan included as Figure 1.

The general soil profile indicated by the available test boring data indicate the following strata in order below ground surface:

- 1) Fill
- 2) Organic silt and peat
- 3) Marine deposits consisting of a complex interbedding of fine sands and silty clay, and
- 4) Glacial till.

Glacial till is underlain by bedrock which is assumed to consist of a sedimentary shale deposit known locally as "Cambridge Argillite". Generalized soil profiles drawn along the section lines on Figure 1 are presented on Figure 2.

2-03. GROUNDWATER LEVELS

Groundwater levels have been measured in observation wells installed at the eastern perimeter of the site as part of the Four Seasons Hotel project. In addition, an observation well was installed in test boring B-1 at the corner of Providence and Arlington Streets as part of the recent test boring program.

Data from the Four Seasons project wells indicate normal static groundwater levels ranging from El. +4.5 to El. +0.5. The water level monitored at test boring B-1 is approximately at El. +6.

III. TENTATIVE FOUNDATION REQUIREMENTS

3-01. FOUNDATION SUPPORT SYSTEM

The following information regarding the configuration of the structure has been received:

Building height:	8 to 12 stories
Average dimensions:	130 ft. by 355 ft.
Column spacing:	Varies, 28 ft. typical
Basement levels:	Two basement levels under the entire project site.

The miscellaneous fill, peat and organic silt which underlie this site are unsuitable materials for foundation support. It appears that the bottom of the organic soils may vary from El. -5 along portions of Boylston Street to El. -20 at the corner of Providence and Arlington Streets.

The proposed structure must bear on foundation units which extend deeper, such as piles. The type and capacity of individual piles must be selected such that they will provide 1) adequate structural support and 2) extend to a depth such that they do not undergo significant post-construction settlement due to compression of weaker underlying soils. It is not technically feasible to support high capacity bearing piles within the marine deposits (Stratum C) because of its complex stratification.

Therefore, it appears that there are two options regarding feasible pile types:

- Option 1. Pressure-injected footings (PIF's) as installed by Franki Foundation Company. The design bearing capacity should be reduced below the normal 120 ton capacity in view of anticipated bearing soil properties, subject to the results of further boring investigations and pile load testing.
- Option 2. End-bearing piles driven to bearing in the glacial till or bedrock. The pile types that should be considered include steel H-piles, precast/prestressed concrete piles and concrete-filled pipe piles. The capacity of these units would be approximately 124 to 134 tons.

Recommendation:

Based on our experience at the adjacent Four Seasons site, we recommend for current planning purposes Option 1. In view of the successful load tests, a PIF capacity of 75 tons should be used for estimating pile quantities.

Alternate Foundation System:

It is important to note that a mat-type foundation system bearing on the marine deposits underlying the organic soils may also provide a suitable foundation alternate. These soils currently support the seven story 250 Boylston St. building. Although not currently recommended in this report, a mat foundation system will be investigated as part of the final design study when additional information on the depth and extent of organic soils and consolidation/ strength characteristics of the underlying clay soils are evaluated.

IV. CONSTRUCTION CONSIDERATIONS

4-01. PROBABLE EXCAVATION SUPPORT SYSTEMS

Due to the proximity of the excavation limits to existing public streets and active utilities, plus the fact that it will extend to depths of up to 20 ft. through soft organic soils and some 15 ft. below the groundwater level, open cut slopes are not feasible for any portion of the proposed excavation.

In our opinion, the required retention system would consist of an internally braced, continuous steel sheet pile system. For current planning purposes, we have assumed that sheeting must be driven to El. -25. Properly designed and installed, such a system will help maintain surrounding water levels and minimize groundwater flow into the excavation, while providing adequate excavation support.

Based on our review of the subsurface information and site geometry, we feel that the lateral support of the sheet pile wall should be provided by a system of both external tiebacks and internal bracing.

Due to the close proximity of the excavation to the Boylston Street subway, thickness of organic soils and the existence of steel sheeting and pressure injected footings at the Four Seasons Hotel project, external tiebacks do not appear feasible along Boylston Street or Hadassah Way. A system of inclined raker braces reacting against completed pile caps would provide the most suitable internal bracing system in these areas.

In view of the advantages of greater interior working space which results from the use of tiebacks, their use may still be considered for use along the south and east sides of the project.

4-02. FOUNDATION INSTALLATION

Our past experience at the Four Seasons Hotel project has indicated that the use of pressure injected footings (PIF's) at reduced design loads would provide a suitable foundation system. It is necessary that PIF's be installed to bear in granular soils. Layers of suitable materials may be found as part of the complex interbedded marine deposits. In order to accurately locate and contour this "potential PIF bearing stratum", an extensive program of subsurface explorations must be undertaken.

A series of approximately 30 test borings utilizing continuous sampling techniques should be completed as part of the final design phase of the project. Data from these test borings will provide the necessary information for determining the depth to which each PIF must be installed.

Based on technical considerations the individual PIF's for the Four Seasons Project were designed to support 60 tons each. In view of the results of four load tests and installation of production PIF's at that site, it is recommended that a higher capacity of 75 tons be considered for the Arlington/Hadassah site. The final design capacity must be confirmed by load tests.

Production PIF installation should be planned and conducted in such a manner as to take into consideration the following:

1. The differential bearing levels between PIF's should be no greater than 1-1/2 horizontal to 1 vertical to avoid overloading of adjacent PIF's.
2. Pre-drilling of PIF's may be required in areas where test boring data indicate significant amounts of fine grained, saturated, slow-draining soils in order to minimize heave during displacement driving.
3. Heave of completed PIF shafts should be monitored during installation of adjacent PIF's to assure that completed PIF shafts have not been damaged by heave.

4-03. DEWATERING

The steel sheet piling to be driven around the site perimeter may allow nominal leakage of groundwater through the interlocks in the sheeting. In addition, some groundwater may flow upwards into excavations which penetrate through the organic stratum into the fine sands and silts. However, a carefully designed and installed sheet pile system should reduce seepage gradients such that relatively little yield is expected from the bottom of the excavation. Therefore, it is believed that dewatering may be accomplished by open pumping from inside the excavation. Note that pumping must continue until such time that the constructed basement can withstand full normal uplift pressures.

For the proposed depth of excavation and planned long-term dewatering periods, it is probable that a minor drawdown of surrounding water levels may occur. The primary concern for drawdown is its potential effects on structures which are supported on untreated wood piles. Dewatering below pile cut-off levels (nominally El. +5) would subject them to drying and possible decay. In addition, lowering of water levels may also cause settlement of soil supported floors, streets and/or utilities which are underlain by highly compressible organic soils.

It is not considered necessary to require a recharge system in the area. It is our opinion, however, that several observation wells be installed around the site prior to construction as was done at the Four Seasons Hotel Project. This will provide a means of monitoring water level changes and provide a basis for evaluating the need for recharge or modifications to dewatering procedures as the work progresses.

V. "PREMIUM" COSTS ASSOCIATED WITH FOUNDATION CONSTRUCTION

5-01. ASSUMPTIONS AND CONDITIONS

The BRA has requested that an estimate be prepared of "premium" costs related to construction of the foundation system.

For this purpose, we have defined the premium costs as the difference between the estimated costs for site preparation and foundation construction for the proposed structure at two locations:

- 1) At the Arlington/Hadassah parcel.
- 2) At an urban site in Boston, where there are no significant site access or obstruction problems, and subsurface conditions are such that the same structure can bear on spread footing foundations at shallow depths.

Site conditions and proposed construction are discussed earlier in this report. The important items which we would consider to be in the category of "premium" costs include the following:

A. Site Preparation

1. Cost for Continuous steel sheet piling, driven around the entire perimeter, to penetrate at least 5 ft. into impervious clay.

Less: Nominal soldier pile and lagging system.

The reason is that 1) the saturated fill and organic soils cannot be effectively retained by a lagging system, and 2) relatively tight steel sheeting is required to minimize draw-down of groundwater levels in the vicinity. It is important to maintain water levels in the Back Bay to control potential street and utility settlement and not expose wood piles to drying.

2. Cost for Temporary internal raker bracing system to support sheeting in certain areas.

Less: Nominal soil tieback system.

The reason is that tiebacks cannot be installed along the Boylston Street side due to the presence of the MBTA subway. Also, it is unlikely that tiebacks can be used along Hadassah Way, due to the steel sheeting and PIF foundations at the Four Seasons project. The use of rakers presents restrictions to construction activities within the site, which must be considered.

3. Cost for Groundwater control, dewatering, monitoring in the vicinity, and uplift control during construction.

Less: Nominal sump pit dewatering.

The reason is that dewatering is critical at this site. The excavation will require dewatering at least 15 ft. below normal levels and must be maintained during construction until such

time as there is adequate dead weight to counter-balance uplift pressures. Monitoring is essential to observe the potential drawdown in the surrounding neighborhood.

4. Cost for Obstruction removal during excavation, includes vaults, old foundations, wood piles, etc.

The reason is that the site has been totally occupied by buildings, for which old foundations, including piles and caissons will remain in place and must be removed for new construction. Also included is pre-excavation along the perimeter sheeting alignment. The excavated materials are unsuitable for re-use and must be disposed of off site.

B. Foundation System

1. Cost for Pile foundations (based on 75-ton capacity for each pile).

Less: Spread footings, designed for 4 tons per sq. ft.

The reason is that piles are needed because the existing soils at subgrade level are not adequate. Pressure injected footings (PIF's) at a reduced capacity of 75 tons each are anticipated, driven to depths estimated from both the historic and recently obtained test boring data. This design capacity is less than the standard 120 tons because the PIF bearing materials are somewhat weaker and finer grained than normal and, in some areas, underlain by clay such that the stresses applied to the clay should be reduced.

2. Cost for Structural slab at the lowest level, designed for hydrostatic pressures at El. +8.

Less: Normal slab-on-grade construction.

The reason is that a structural slab is required to resist hydrostatic pressures at this site and for structural reasons. At an "ideal" site, the basement could normally be designed as an earth-supported slab.

3. Cost for Waterproofing of slab and walls.

Less: Nominal damp-proofing.

The reason is that the proposed two basement levels below grade are approximately 15 ft. below normal groundwater levels.

5-02. ESTIMATED PREMIUM COSTS

Based on our review of the project and the assumptions and conditions pertaining to an ideal site vs. the Arlington/ Hadassah project, we have prepared the following Table I which summarizes our estimate of "premium" foundation costs.

TABLE I

ESTIMATED "PREMIUM" FOUNDATION COSTS
ARLINGTON/HADASSAH PROJECT

ITEM NO.	ESTIMATED COST FOR	LESS ESTIMATED COST FOR	ESTIMATED PREMIUM COST
<u>SITE PREPARATION</u>			
A-1	Continuous steel sheet piling system	Soldier pile and lagging system	\$ 155,000
A-2	Temporary internal raker bracing system in certain areas	Nominal soil tieback system	\$ 30,000
A-3	Groundwater control	Sump pit dewatering	\$ 108,000
A-4	Obstruction removal during excavation	Normal excavation	\$ 84,000
<u>FOUNDATION SYSTEM</u>			
B-1	Pile foundations (PIF's)	Spread footing foundations	\$ 895,000
B-2	Structural slab	Slab-on-grade	\$ 395,000
B-3	Waterproofing slab and walls	Nominal damp-proofing	\$ 50,000
		TOTAL ESTIMATED PREMIUM FOUNDATION COST	<u>\$ 1,717,000</u>

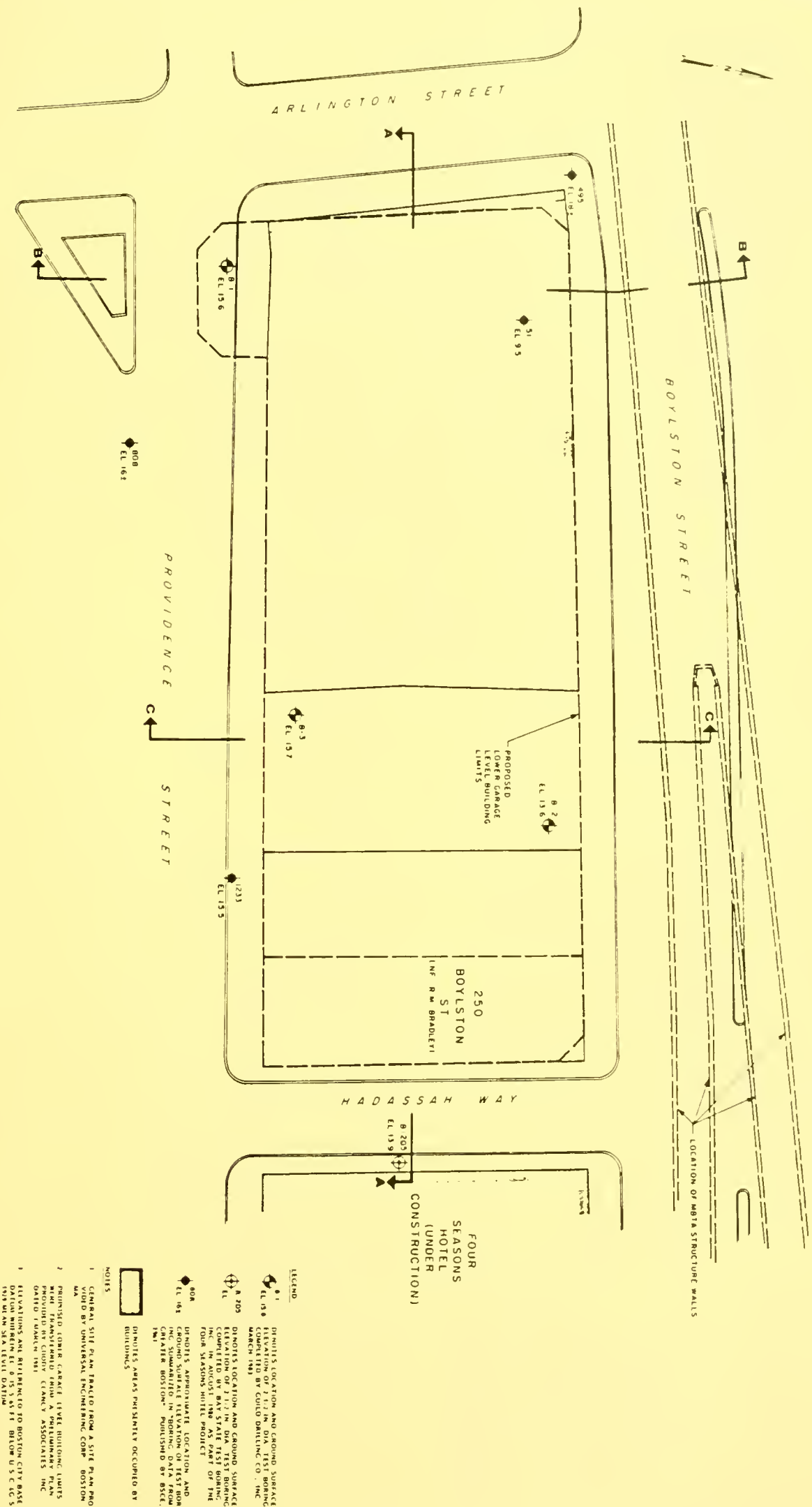


FIGURE 1

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